The DEEP Project: DEtecting Extraterrestrial Piezophiles in Ocean World Analogs

Completed Technology Project (2017 - 2020)

Project Introduction

OBJECTIVES : Searching for extraterrestrial life necessitates a better understanding of the unique aspects of life detection in the high-pressure, deep oceans of Europa, Enceladus, and Titan. Generally, Earth's oceans are similar to these extraterrestrial ocean worlds, but the closest analogs are deep-sea hydrothermal vents where microbes cycle nutrients and energy across a range of geochemical conditions. All of these ecosystems share one central physical parameter - high hydrostatic pressure - and piezophily is the common characteristic of life in the deep ocean. This high-pressure adaptation confers a competitive advantage to piezophiles, allowing them to access additional energy sources and expand habitable niches. While deep-sea microbes have been studied extensively, obligate piezophiles remain elusive, excluded by traditional decompressive sampling techniques. Putative microbial communities in the deep oceans of Europa, Enceladus, and Titan would necessarily be piezophiles, therefore instrument development for upcoming missions to ocean worlds must include the ability to (1) detect life under high pressure conditions and/or (2) develop sample handling and life detection analysis protocols that mitigate the effects of sample decompression on analytical outcomes. The DEEP project will take advantage of a new high pressure sampling system (PUSH50) that allows for sample retrieval and manipulation without decompression. Here we propose a field research program to the Earth's deepest hydrothermal vents, the Mid Cayman Rise, in order to develop high pressure sample handling protocols that optimize life detection in high pressure environments. METHODOLOGY: We will evaluate the fidelity of a range of life detection techniques on a variety of deep-sea vent samples for which in situ pressures have been maintained throughout the analytical process, and compare these to parallel samples that have been subjected to standard decompressive techniques. We aim to: (1) identify the most robust suite of analyses for life detection in high pressure ecosystems; (2) determine the instrumental/analytical requirements for in situ life detection on future ocean worlds missions. In situ detection of microbial communities will include: quantification of cell and biomass; characterization of species and metabolic diversity; enrichment cultivation for high value target metabolisms; and measurement of geochemical isotopic biosignatures. Many of these techniques can be (and are currently being) adapted for remote deployment on landers and rovers. Our proposed research will identify which of these techniques is most robust in high-pressure environments, optimize in situ analysis protocols for high-pressure ecosystems, and develop the technology necessary to implement these protocols in upcoming mission instrument packages SIGNIFICANCE This work addresses the following PSTAR Objectives. Science: We will elucidate the processes by which high pressure microbiomes are sensitive to traditional decompression sampling, characterize the metabolic and species diversity that has been obscured by these techniques, and develop new approaches to detecting these enigmatic piezophiles in high pressure environments. Technology: We will perform the first tests of a newly developed sampling system that maintains high in situ

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Science and Technology Through Analog Research

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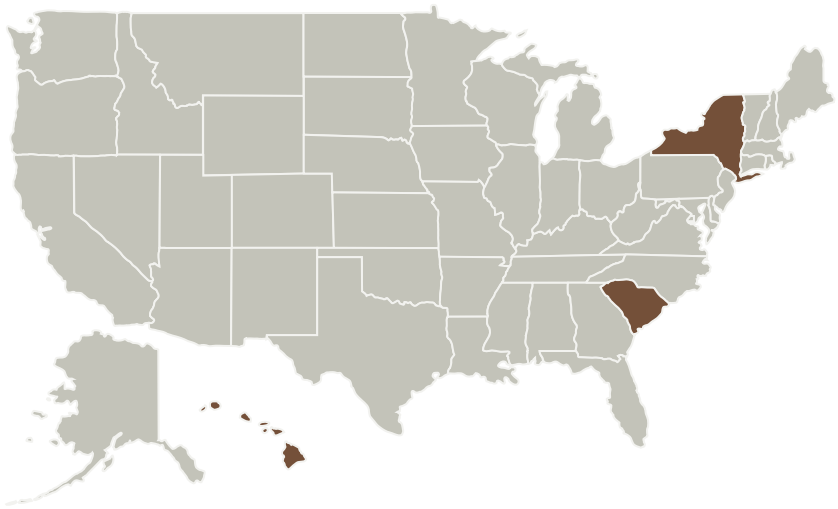
pressures during recovery. We will further develop the technology and protocols necessary for carrying out life detection under high pressures.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Rensselaer Polytechnic Institute	Supporting Organization	Academia	Troy, New York

Primary U.S. Work Locations	
Hawaii	New York
South Carolina	

Project Management

Program Director:
Carolyn R Mercer

Program Manager:
Sarah K Noble

Principal Investigator:
Karyn L Rogers

Co-Investigators:
Susan Q Lang
Jennifer A Rosch
Kiana L Frank

Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.3 Manipulation
    - TX04.3.4 Sample Acquisition and Handling

Target Destination

Others Inside the Solar System